Cognitive-Based Guidelines for Effective Use of Collaboration Tools

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TC3 Workshop

Cognitive Elements of Effective Collaboration

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Cognitive-Based Guidelines
Topics

- Collaboration tool guidelines
  - Opportunity
  - Taxonomies
- Theoretic foundations--the models
  - Purposes
  - Diversity
  - Transactive memory
- Validation
  - Strategies
  - Metrics

Collaboration Definition

Collaboration, as used in this analysis, is

- the mental aspects of joint problem solving for the purpose of achieving a shared understanding, making a decision, or creating a product

Opportunity

- Conditions for highly effective teamwork nearly in place
  - Rich set of collaboration tools
  - High communication connectivity
  - Understanding of cognitive basis of effective teamwork
- However, collaborating teams sometimes do not work well
- Therefore, guidelines for effective collaboration can have a significant impact

Guidelines
Examples from Current Sources

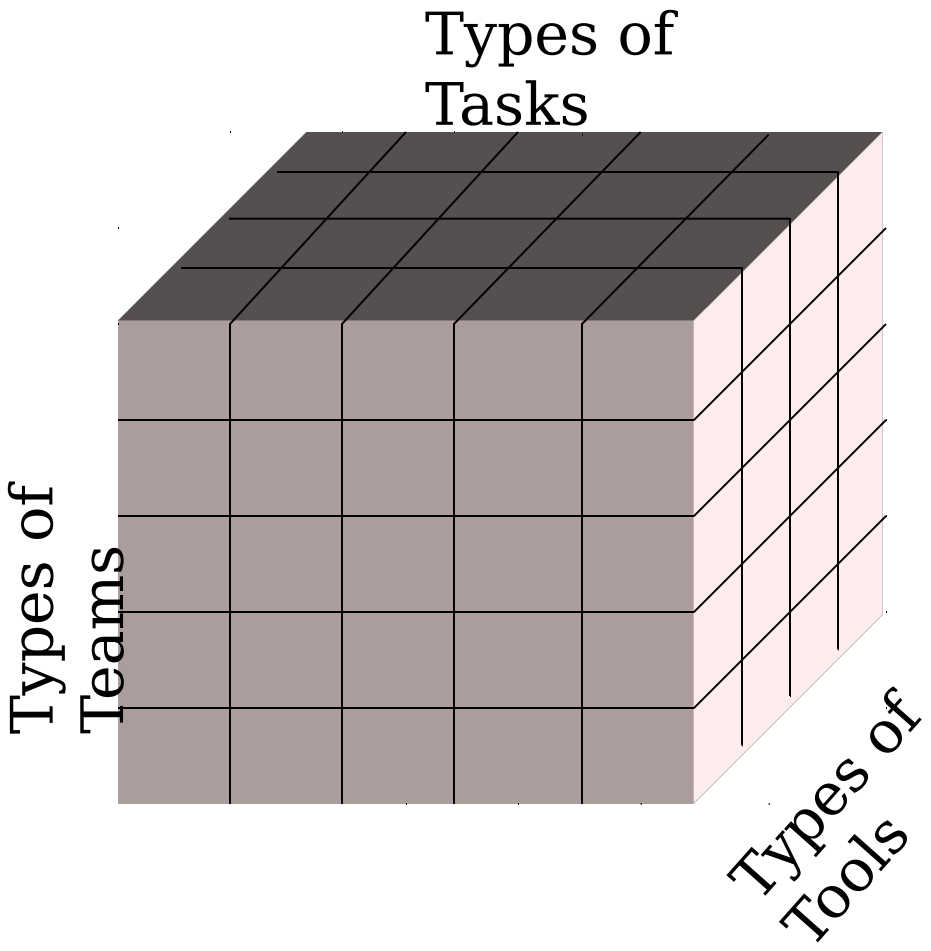
Task/Communication Mode Example (Jens Jensen)

Communication Modes	Generating ideas and plans and collecting data	Problems with answers	Problems without answers	Negotiating technical or interpersonal conflicts
Audio only	Marginal fit	Good fit	Good fit	Poor fit
Video only	Poor fit	Good fit	Good fit	Marginal fit
Data only (e.g., e-mail..)	Good fit	Marginal fit	Poor fit	Poor fit
Multi-user virtual environment	Good fit	Good fit	Good fit	Good fit

- "Expertise location software, audio conferences, web conferences, and other interactive technologies can be as effective as databases for sharing tacit knowledge
- Intranets can be powerful tools for tailoring information and improving organizational performance

Mary Boone. Managing Inter@ctively. Page 159

Taxonomies for Collaboration Environments



- Characterizes types of collaborative tasks, teams, and tools
- Describes collaboration space
- Provides framework for specifying when to apply different types of guidelines

Team Taxonomy Dimensions

- Distribution
- Roles and Functions
- Team Structure
- Team member dependencies
- Information and Information Flow
- Decision Making

Team Taxonomy Examples

Team Dimension	Dimension Subcategories
Distribution	• Physical—spatial separation • Temporal—e.g., working different shifts • Expertise—spatial and temporal distribution of experts and expertise • Information—spatial distribution of information
Team Structure	• Hierarchical vs. flat—extent that team has designated leader in charge or is peer-to-peer • Size—number of members • Permanent vs. ad hoc—extent it works together over extended period of time, or is brought together for one task • Single vs. team-of-teams—extent that teams can be decomposed into collaborating sub-teams • Turn-over—stability of team membership
Team member dependencies	• Independence—extent that each team member depends on other team members to perform his task • Interaction frequency--how often team members must interact • Synchronization—requirement for and schedule tolerance of temporal sequencing of tasks performed by different members • Cognitive—extent that team members must pay attention to each others' tasks • Task sharing—extent to which each team member has own task or all team members share the same tasks • Processing flow-- individual/parallel or sequential

Task Taxonomy Dimensions

- Cognitive domain
- Workload
- Divisibility
- Difficulty

Task Taxonomy Examples

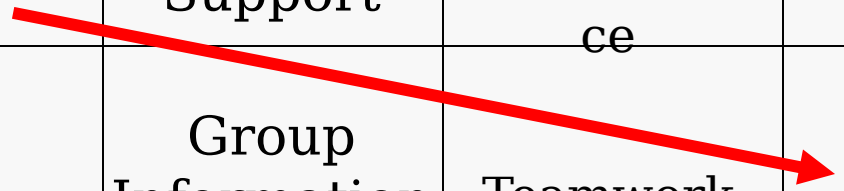
Task Dimension	Dimension Subcategories
Cognitive domain	• Stage(s) of decision making emphasized--goal specification, monitoring, situation diagnosis, opportunity/problem ID, alternative ID, alternative evaluation, selection • Interaction focus--info exchange, brainstorming, review, negotiation, consolidation, handoff
Workload	• Effort--amount of work required to carry out team assignment • Duration--length of time over which work must be performed • Expertise—amount of expertise work requires for successful completion (extent that work requires specialists) • Degree of reach--extent that assigned work requires tasks carried out at different places and at different times
Difficulty	• Goal clarity--extent that objectives are well defined • Resource clarity--extent that available resources are well specified • Stakes--importance of the outcome • Familiarity—extent that tasks are routine or novel • Information availability--extent that needed information is readily available • Time pressure--extent that task has hard real or perceived deadlines • Transparency--the ease or difficulty required to monitor the tasks status or progress • Stability—extent that tasks, resources, and information requirements may change in response to new opportunities and problems

Tool Taxonomy

- General purpose group communication tools
  - E-mail, video and audio conferencing, shared white board, shared documents and databases, bulletin boards, news groups, web pages, “sticky notes,” chat rooms
- Special purpose facilitators of group processes
  - Electronic meeting systems, brainstorming, negotiation, review and editing, idea enrichment tools
- Shared work and group sense making tools
  - Tailored interactive visualizations of shared data
- Process support tools
  - Workflow managers, electronic document management, calendar support, collaborative planning, plan monitors, dialog managers, audit trail managers, expert finders, mail lists

Modeling Goal

Individual Understandings	Individual Information Interaction Support	Individual Task Performance	Individual Products
Team Understandings	Group Information Interactions	Teamwork	Team Products



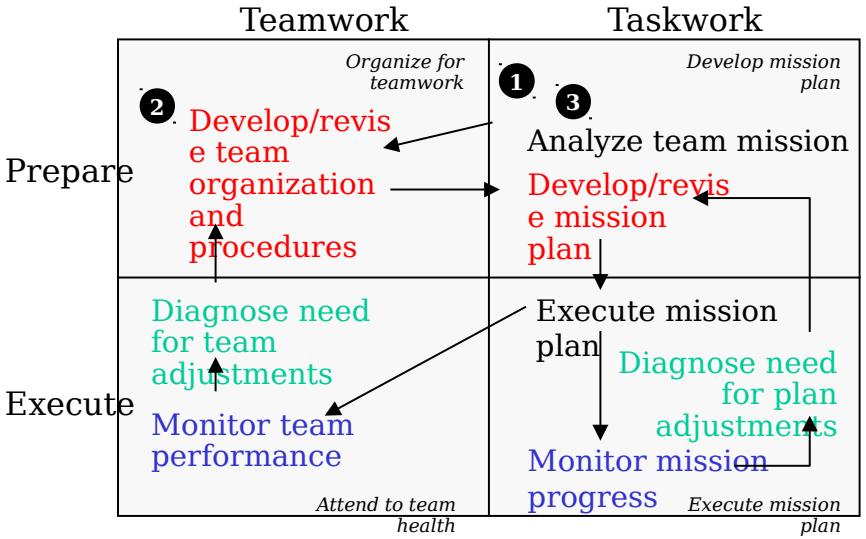
Modeling goal: Describe mechanisms that connect individual understandings to the quality and timeliness of team products and to team efficiency

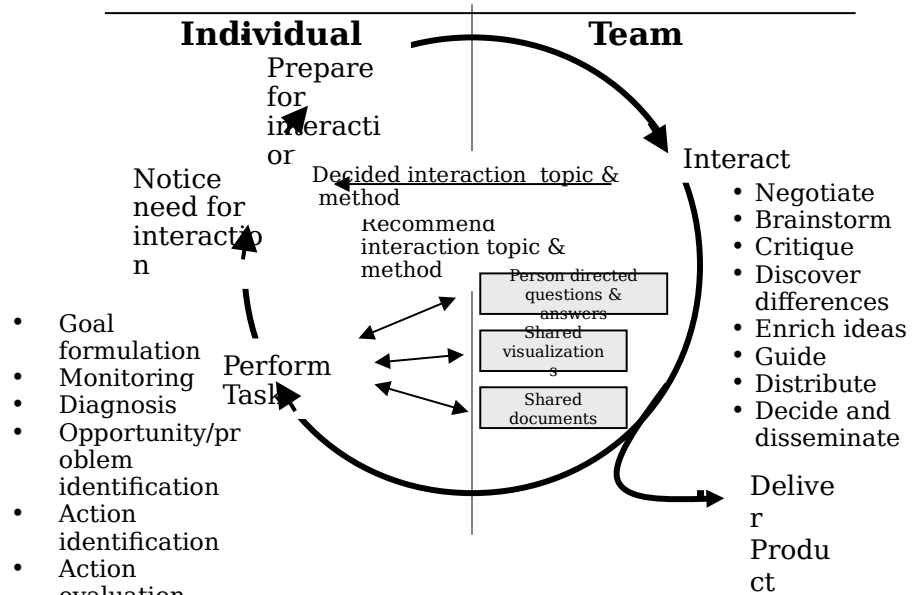
Need for Complementary Collaboration Models

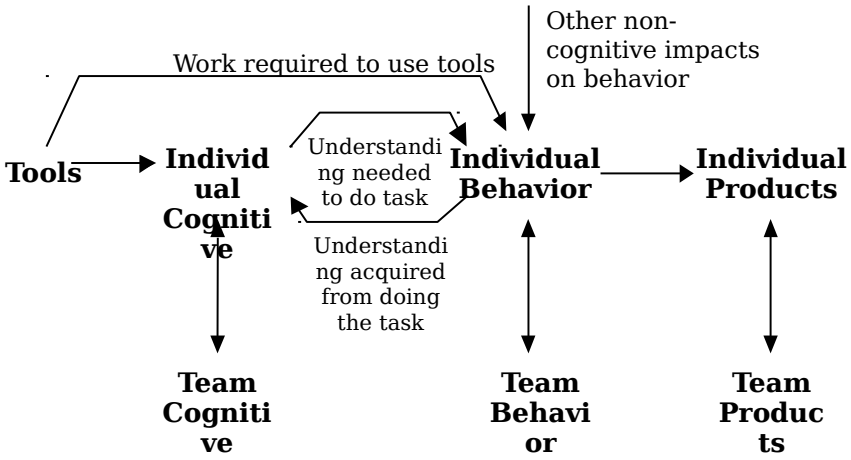
- No model can likely address all aspects of collaboration
- However, a set of complementary models, each addressing different aspects of the same underlying process, can
- Five models of value to the SBIR are
  - **Teamwork and Taskwork**: all teams engage in activities to develop tasked product and to maintain team health
  - **Feedback:** teams must monitor progress and make corrections for both teamwork and taskwork
  - **Individual/Team Interplay**: many collaborative tasks call for a cycle of individual and group processes
  - **Coupling Cognition, Behavior, and Products**: team processes and products emerge from individual understandings, behaviors, and products
  - **Transactive memory**: the relationship among team member's individual understandings drives the quality of team performance

Complementary Collaboration Models

	Teamwork Team organization and maintenance	Taskwork Accomplishing mission goals
Prepare	**Organize for teamwork** • Agree on goals • Identify tasks • Assign roles • Develop schedule • Identify interaction criteria and methods	**Develop mission plan** • Analyze mission • Identify tasks • Allocate tasks • Develop schedule • Assign resources • Identify constraints • Develop contingencies
Execute	**Attend to team health** • Monitor team processes • Cue and alert to possible problems • Diagnose nature of team problem • Reengage "organize for teamwork"	**Execute mission plan** • Monitor • Assess situation • Decide on needed plan adjustment • Issue directives • Execute / develop products

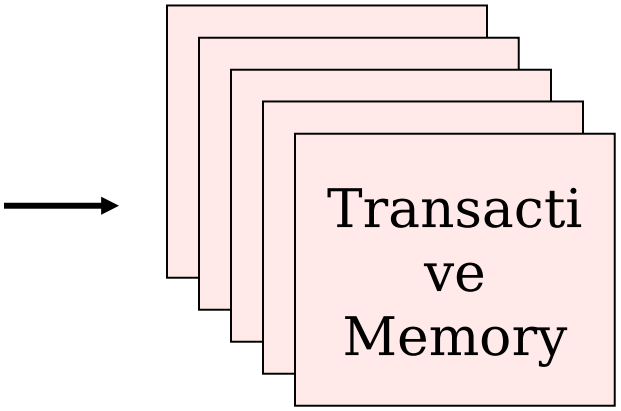






Transactive Memory As a Key Intervening Variable

Exchange ideas and develop consensus

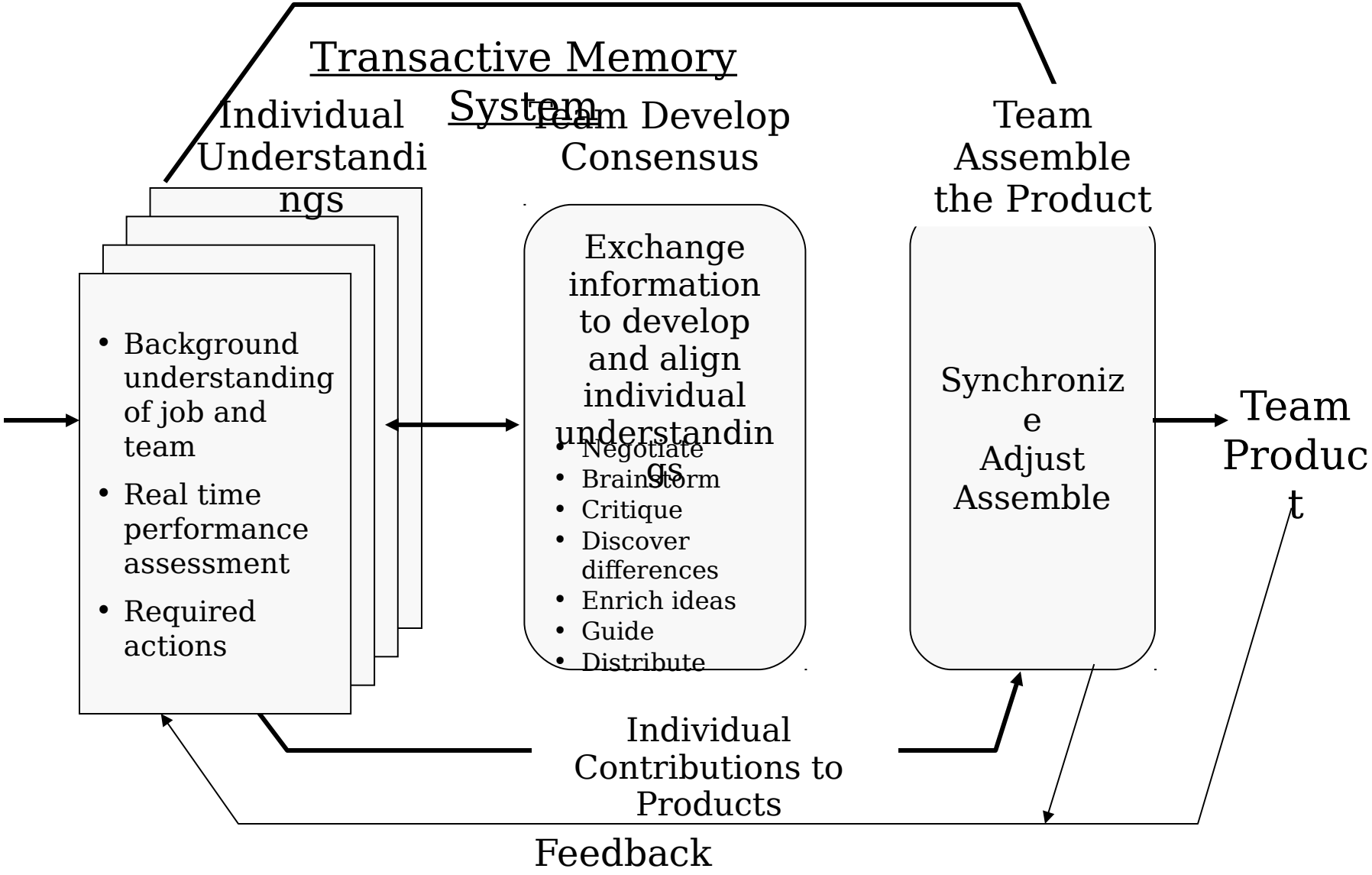


Synchroniz e and assemble the product

Transactive memory is the distribution of knowledge within a team

It functions as a powerful intervening variable between group discussions and group behaviors

Transactive Memory Model



Individual Understandings

Organization to Support Teamwork and Knowledge Sharing

Meta memory	Private memory	Shared information	Transactive information	Consensus items
Team member's assessment of his ability to recognize when knowledge is needed and to recall and use his knowledge	What team member knows about that though not expected to be needed in this particular joint action could be critical	Items that a person is responsible for knowing within the team, and that others know he's responsible for. Multiple team members can share responsibility	Items team member knows that somebody else is responsible for, and knowledge of how to obtain that information	Things that the team has decided

Guideline Validation

- Strategies: a combination of
  - Assessments of experienced practioners
  - Observations from exercises or wargames with “natural” control
  - Hypothesis testing experiments with control group
  - Validation of model/theory that guidelines are based on
- Metrics are key element of validation

Metrics

Individual Understandings	Individual Information Interaction Support	Individual Task Performance	Individual Products
Team Understandings	Group Information Interactions	Teamwork	Team Products

Metrics
Product and Team Efficiency

- Bottom line “proof of the pudding” metrics
- Metrics for a particular product are the same, whether produced by an individual or a team
- Examples
  - Product timeliness
    - Timeliness of product production--product completion time relative to deadline
  - Product quality metrics (plan example)
    - Useful life of plan compared to its intended useful life. No plan “survives contact with the enemy,” but better plans last as long as intended
    - Fraction of commander’s objectives that plan addresses
    - Fraction of plausible contingencies covered by plan
  - Team efficiency
    - Total amount of time required to complete the product
    - Person hours to complete product

Metrics
Individual and Team Task Performance

- Individual
  - Measures individual performance in task performance,
  - Behavior categories: task performance, workload, level of engagement, schedule adherence, problem handling, and task flexibility
  - Metric examples
    - Fraction of individual tasks started late
    - Fraction of person's delivered products needing revision
- Team
  - Measures team behaviors
  - Includes roll-ups (computed from individual metrics) and emergent behaviors (not an aggregation property of an individuals' behaviors)
  - Emergent behaviors: team agility, synchronization, "fibrillation," and "friction"
  - Metric examples
    - Time required for team to recognize a problem in teamwork or product development
    - Fraction of preliminary individual products never used

- Examples
  - Fraction of messages received that are relevant
  - Number of cases where sub-teams refuse to share information relevant to others
  - For synchronous collaboration, number of incidents requiring participation by team members not at the meeting
  - Extent that homogeneous, conventional speech patterns used

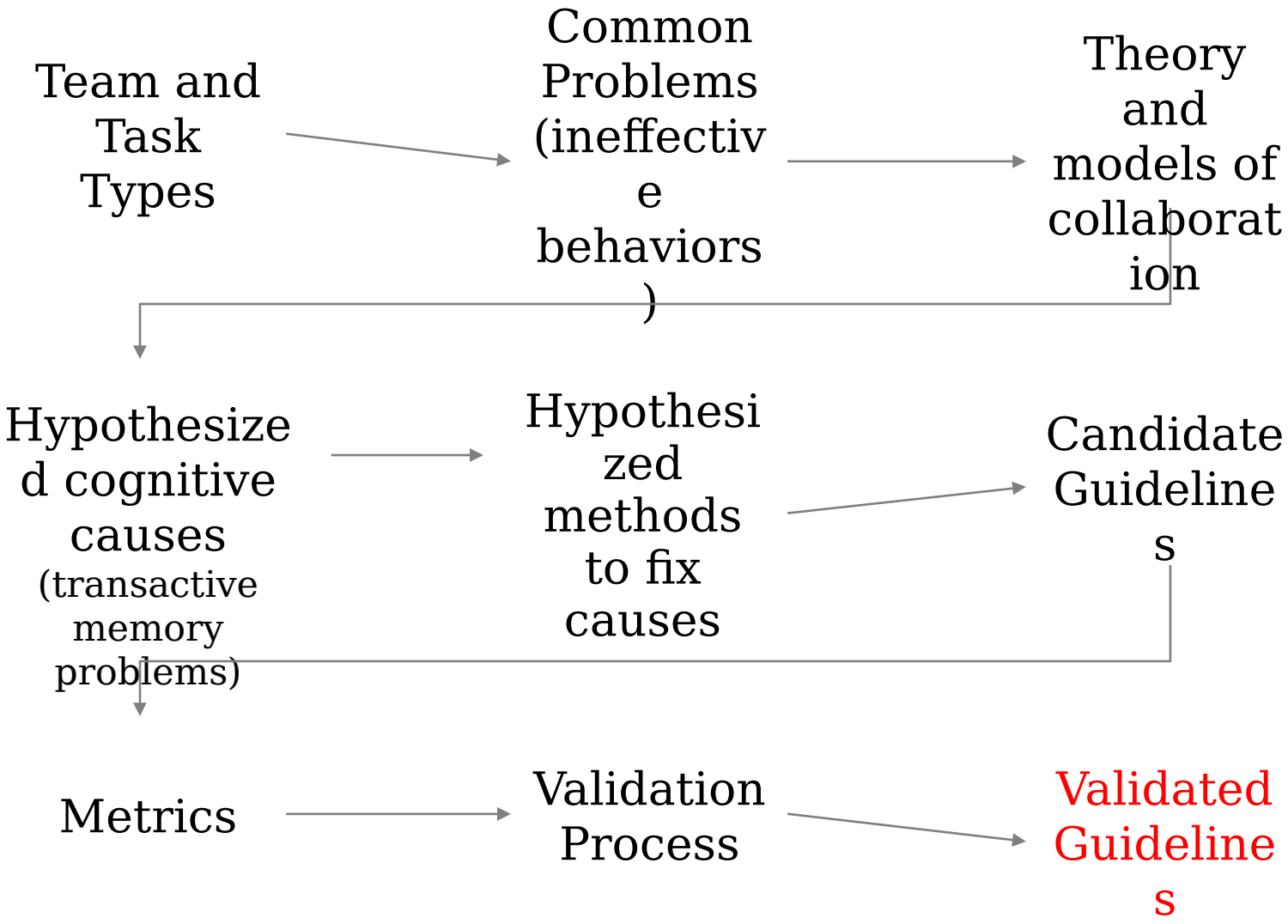
Metrics
Individual and Team Information Interactions

- Individual
  - Measures individual performance to support development of group consensus
  - Includes information acquisition, formulation, and dissemination
  - Metric examples
    - Fraction of times right person asked for information
    - Fraction of time information needed by others conveyed in ways that could be understood without need for clarification
- Team
  - Measures behaviors for consensus building
  - Includes team member participation in brainstorming, idea enrichment, discovery of differences, negotiation
  - Metric examples
    - Fraction of differences in understanding identified
    - Fraction of time spent in meeting not relevant to own responsibilities and not contributing to others

Cognitive Metrics

- Individual metrics
  - Team member understanding of status and processes for teamwork and taskwork
  - Organized into seven cognitive categories
    - Goal formulation, monitoring, situation diagnosis, opportunity/problem identification, identification of candidate actions, evaluation of these candidates, actions selection
  - Examples
    - Correctness of team member understanding of commander's intent
    - Correctness of knowledge of deadlines of decisions
    - Correctness of common ground elements (next slide)
- Team Level metrics
  - Three types
    - Roll-ups average individual cognitive metrics
    - Team coverage measures best knowledge in team and gaps
    - Alignments summarize extent of shared understanding
  - Examples
    - Average accuracy of each team member's estimates of information needed by other team members
    - Consistency and overlap of shared understanding of problem, goals, information cues, and strategies

Summary
Generating Collaboration Guidelines



Backups

Model 1: Teamwork and Taskwork

	Teamwork Team organization and	Taskwork Accomplishing mission goals
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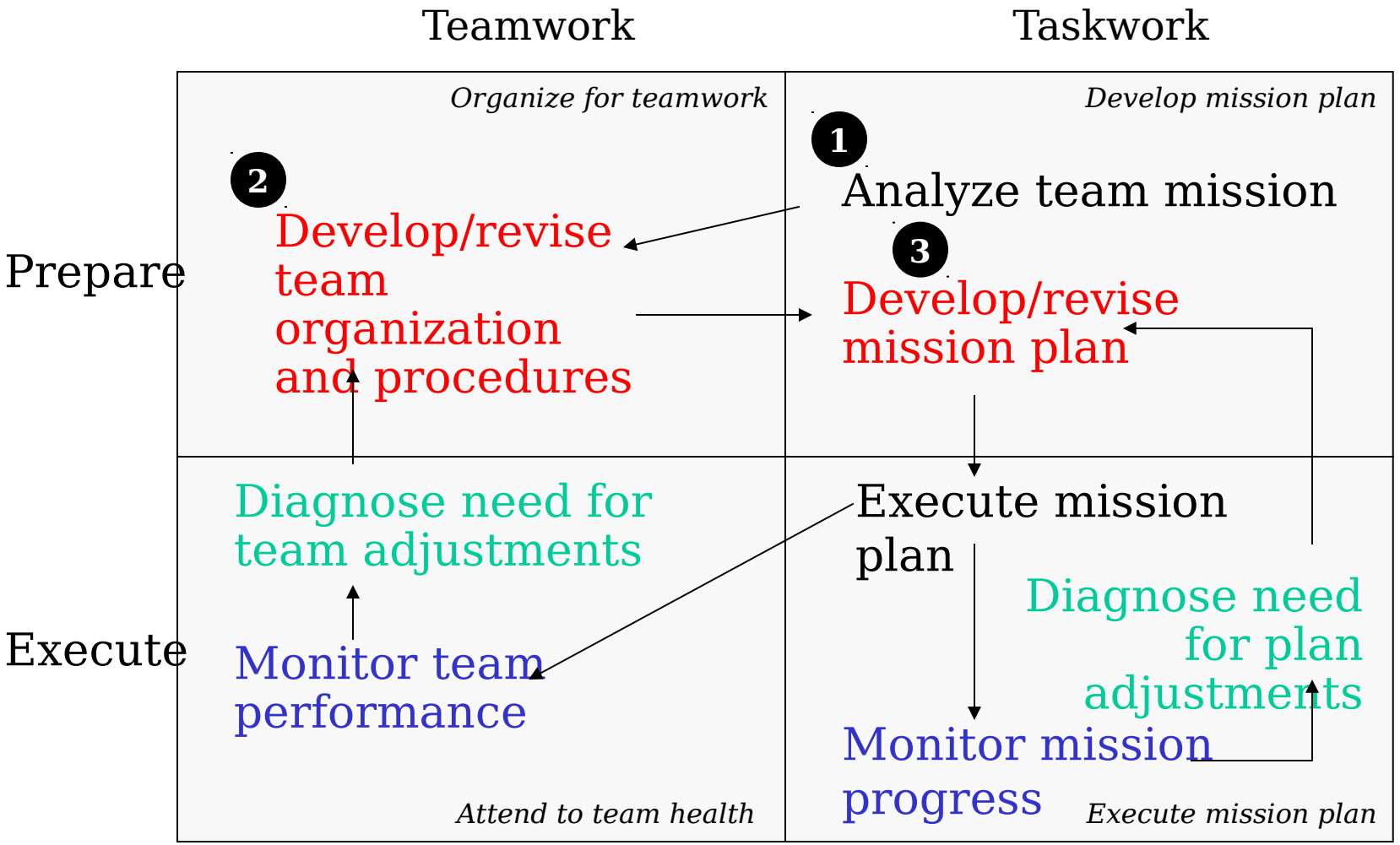
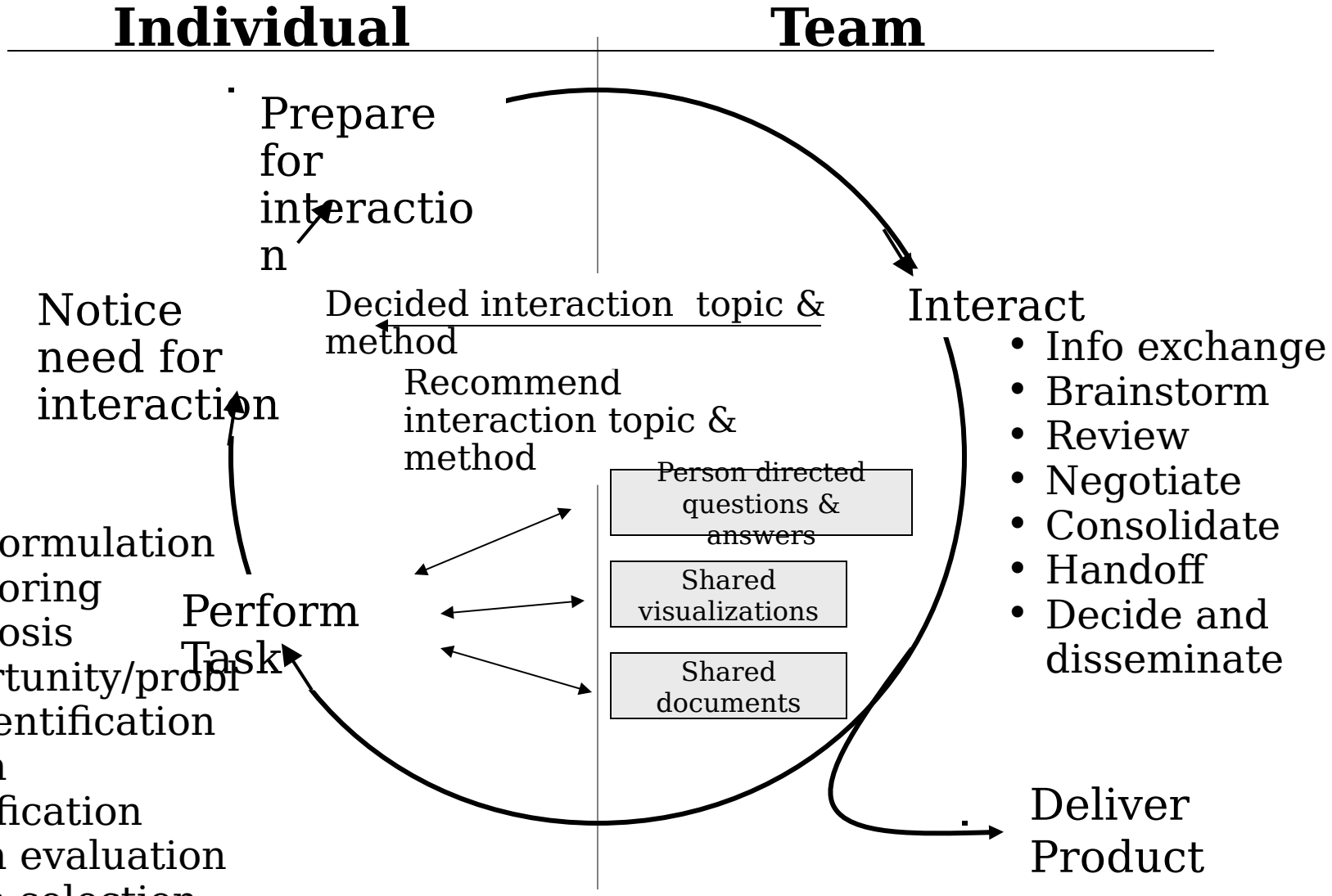
Model 2
Team Planning/Execution Feedback

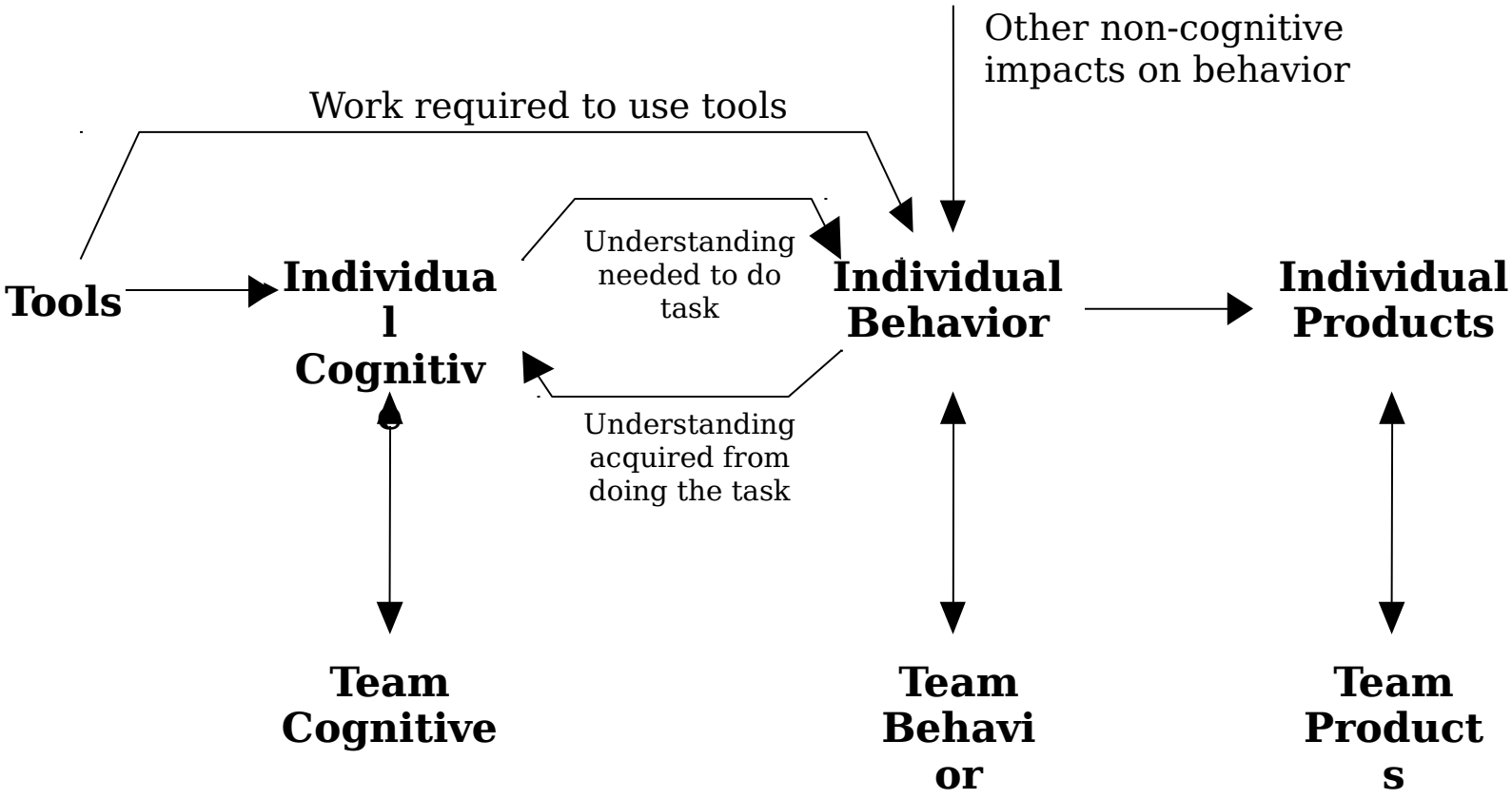


All processes may be accomplished through an interplay of individual

Model 3: Individual/Team Interplay



Model 4
Coupling Cognition, Behavior, and Products



Common Ground

- What each collaboration participant assumes about each other in order to have effective interactions
- Includes each team member's assumptions about other team members'
  - Goals; e.g., where they're coming from
  - Skills, expertise, and information, to include knowledge about the external situation
  - Status, to include workload, fatigue, distraction, level of engagement
  - Degree of commitment and buy-in
  - Cognitive strategies and approach to problem solving